Remote Operations and Collaborative Technologies for Distributed Science

--- HEP & FES ---

Erik Gottschalk (Fermilab) & David Schissel (General Atomics)

Agenda

High Energy Physics (HEP) - Erik Gottschalk

- Remote operations for LHC & planning for ILC
- LHC@FNAL remote operations center

Fusion Energy Sciences (FES) - David Schissel

- FusionGrid for today's domestic program
- Remote operations for ITER

Collaboration between OFES, OHEP, OASCR - Erik & David

LHC at CERN - Geneva, Switzerland

Fermilab - Batavia, Illinois

Remote Operations for HEP: LHC@FNAL

Erik Gottschalk

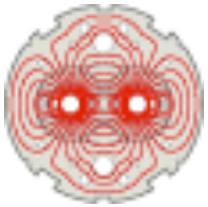
Fermilab - Particle Physics Division

Overview

High Energy Physics

- HEP Remote operations
- What is LHC@FNAL?
- Current status of HEP remote operations capabilities & collaborative tools
- Future capabilities to improve remote operations

HEP Remote Operations

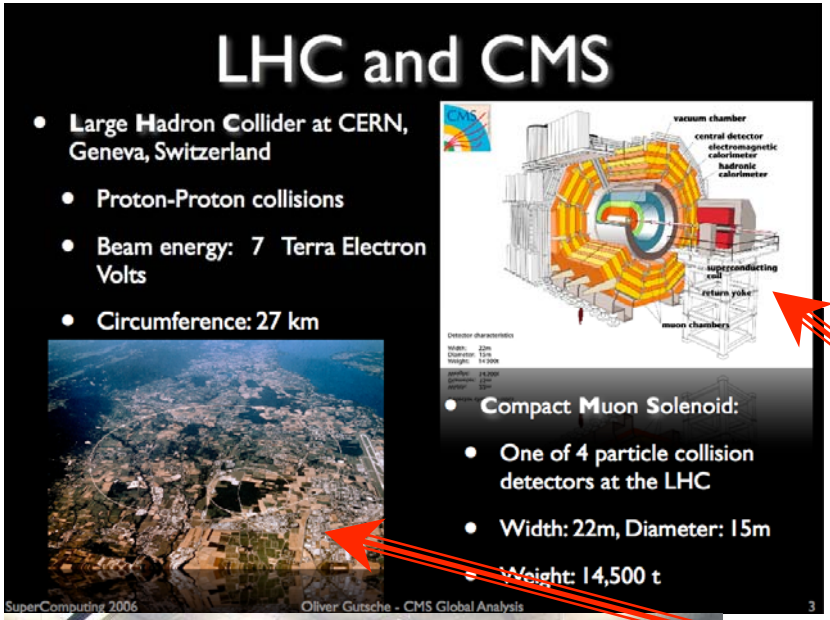


With the growth of large international collaborations in HEP, the need to participate in daily operations from afar has increased.

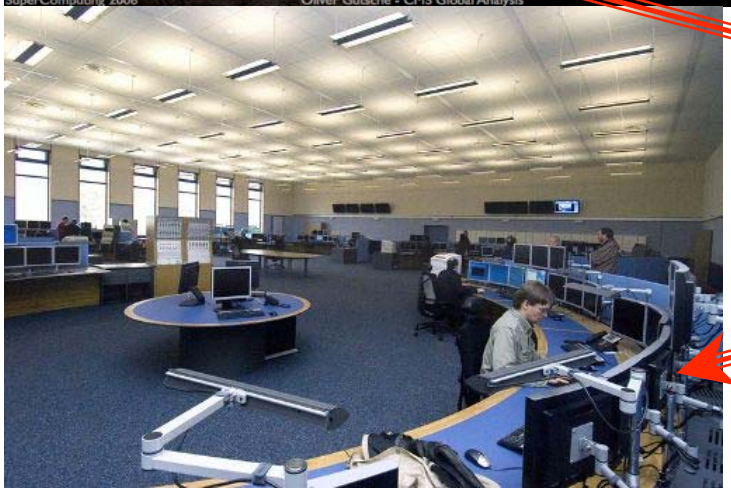
Remote monitoring of experiments is nothing new. In fact, the internet has made it relatively easy to check on your experiment from almost anywhere.

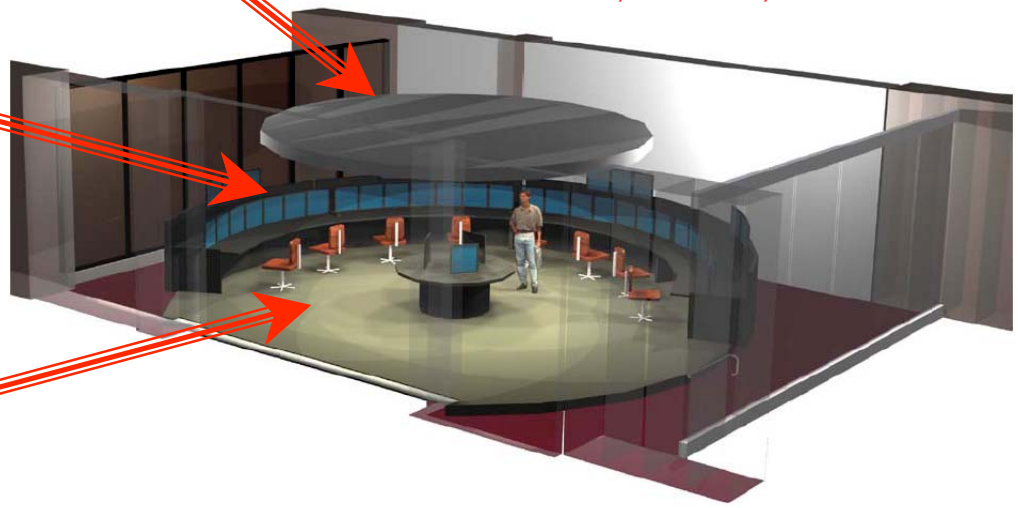
Remote operations is the next step to enable participation of collaborators from anywhere in world - the goal is to take on and accept responsibility for remote shifts.

U.S. Gateway to the LHC at CERN

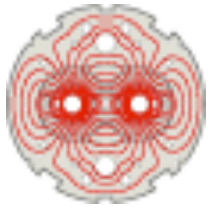


LHC@FNAL remote operations center, Batavia, Illinois



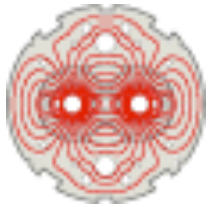


Key components for remote operations



- For successful participation in operations at a distance, collaborations must first address issues of *trust* and *communications*.
- These issues can be partially addressed through choices of appropriate *technologies,* and the establishment of collaboration *policies*.
- A successful long-term remote operations center takes a strong commitment from the local *community,* and the right *environment*.
- Exchange of *personnel* between sites is important, since *nothing* can replace time spent at the experiment.
- The *principal goal* is to enable people to participate in operations when they are unable to travel (high cost of travel, family, visa, cost of living, etc.) to the experiment.

Concept of an LHC remote operations center at Fermilab



Fermilab

- has contributed to CMS detector construction,
- hosts the LHC physics center for US-CMS,
- is a Tier-1 computing center for CMS,
- has built and delivered LHC machine components, and
- is part of the LHC Accelerator Research Program (LARP).

The LHC physics center (LPC) had planned for remote data quality monitoring of CMS during operations. Could we expand this role to include remote shifts? What are the limitations?

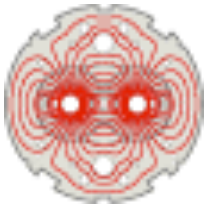
We saw an opportunity for US accelerator scientists and detector experts to work together to contribute their expertise during the commissioning of the LHC. Could they help commission the LHC without moving to CERN for a year?

The idea of a joint remote operations center at Fermilab emerged, and people from each area joined together to develop a plan for a single center (LHC@FNAL).

What is LHC@FNAL?

- A Place
  - That provides access to information in a manner that is similar to what is available in control rooms at CERN
  - Where members of the LHC community can participate remotely in LHC and CMS activities
- A Communications Conduit
  - Between CERN and members of the LHC community located in North America
- An Outreach tool
  - Visitors will be able to see current LHC activities
  - Visitors will be able to see how future international projects in particle physics (such as the ILC) can benefit from active participation in projects at remote locations.

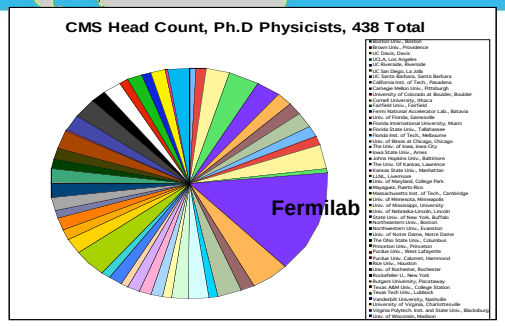
Planning for LHC@FNAL



- We formed a task force with members from all FNAL divisions, university groups, CMS, LARP, and LHC. The advisory board had an even broader base.
- The LHC@FNAL task force developed a plan with input from many sources including CMS, LHC, CDF, D0, MINOS, MiniBoone and Fusion Energy Sciences.
- We worked with CMS and US-CMS management, as well as members of LARP and the LHC machine group at all steps in the process.
- A detailed requirements document for LHC@FNAL was prepared and reviewed in 2005.
- A WBS was prepared, and funding for Phase 1 was provided by the Fermilab Director.
- We visited 9 sites (e.g. Hubble, NIF, SNS, General Atomics, ESOC) to find out how other projects build control rooms and do remote operations.
- We are now engaged in construction, integration, software development and outreach activities. The CMS Remote Operations Center is already in operation.
- The goal is to have LHC@FNAL ready for detector commissioning and startup of beam in 2007.
- We plan to work with the ILC controls group to develop plans for ILC remote operations. This could be used to support test facilities, such as ILCTA at Fermilab.

US-CMS and remote operations

The remote operations center will serve the US-CMS community.



There are nearly 50 US institutions in CMS, and approximately 600 signing physicists/engineers/guest scientists in the US.

The LHC Physics Center (LPC) provides a place in the US for physics/analysis discussions and meetings. CMS remote operations at Fermilab will provide a US hub for operations activities.

CMS collaborators could take shifts at the center.

CMS Remote Operations Center

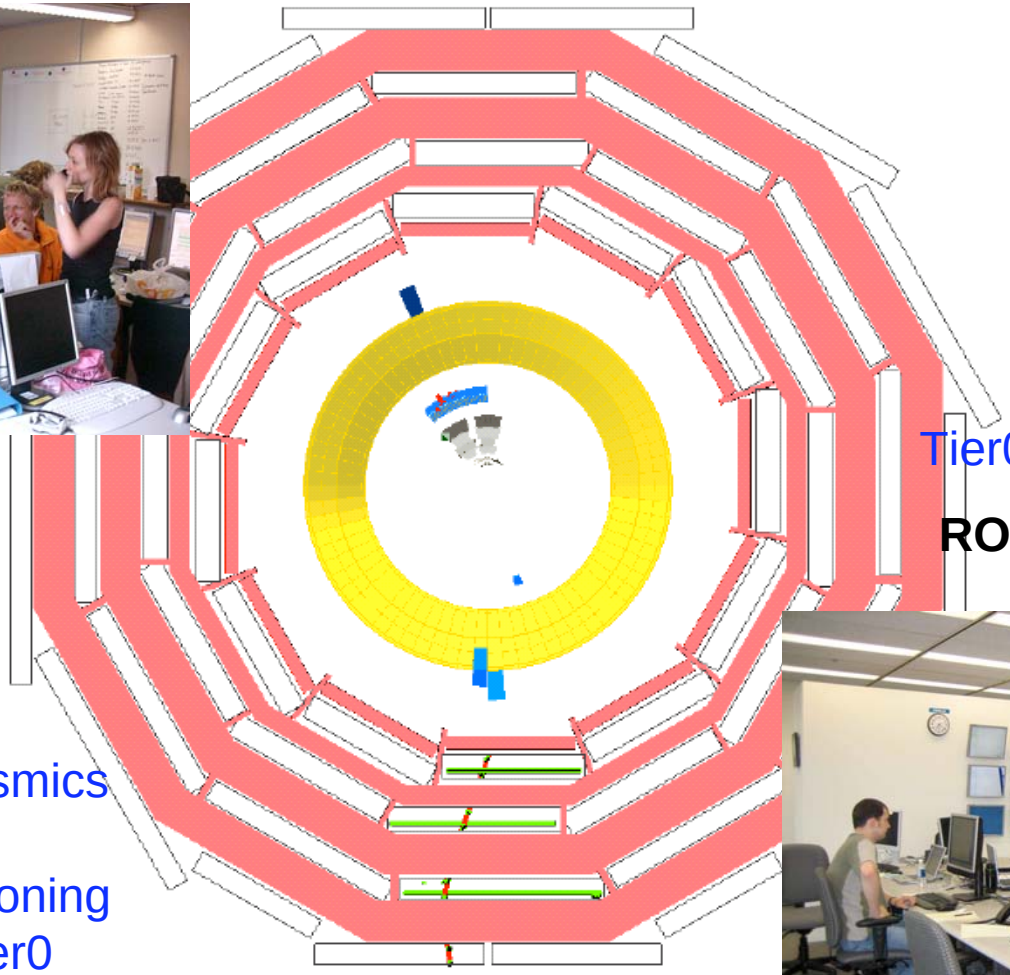
The LHC Physics Center (LPC) first developed the idea of a remote operations center for CMS at Fermilab. The center is already in operation for cosmic tests of the full detector in the surface building at LHC Point 5.

US-CMS remote operations will move to LHC@FNAL center early next year.

CMS ROC web page:
http://www.uscms.org/LPC/lpc_roc

Remote operations for CMS Magnet Test Cosmic Challenge (MTCC)

CMS temporary Control Room at CERN P5



Data quality monitoring

Software tests

Tier0-Tier1 transfers

ROC at Fermilab

MTCC@CERN
Integration test
Detector tests with cosmics
Field mapping
Global DAQ commissioning
Data Transfer to Tier0

Summer-Fall 2006

CMS Magnet Test Cosmic Challenge (MTCC) at FNAL ROC

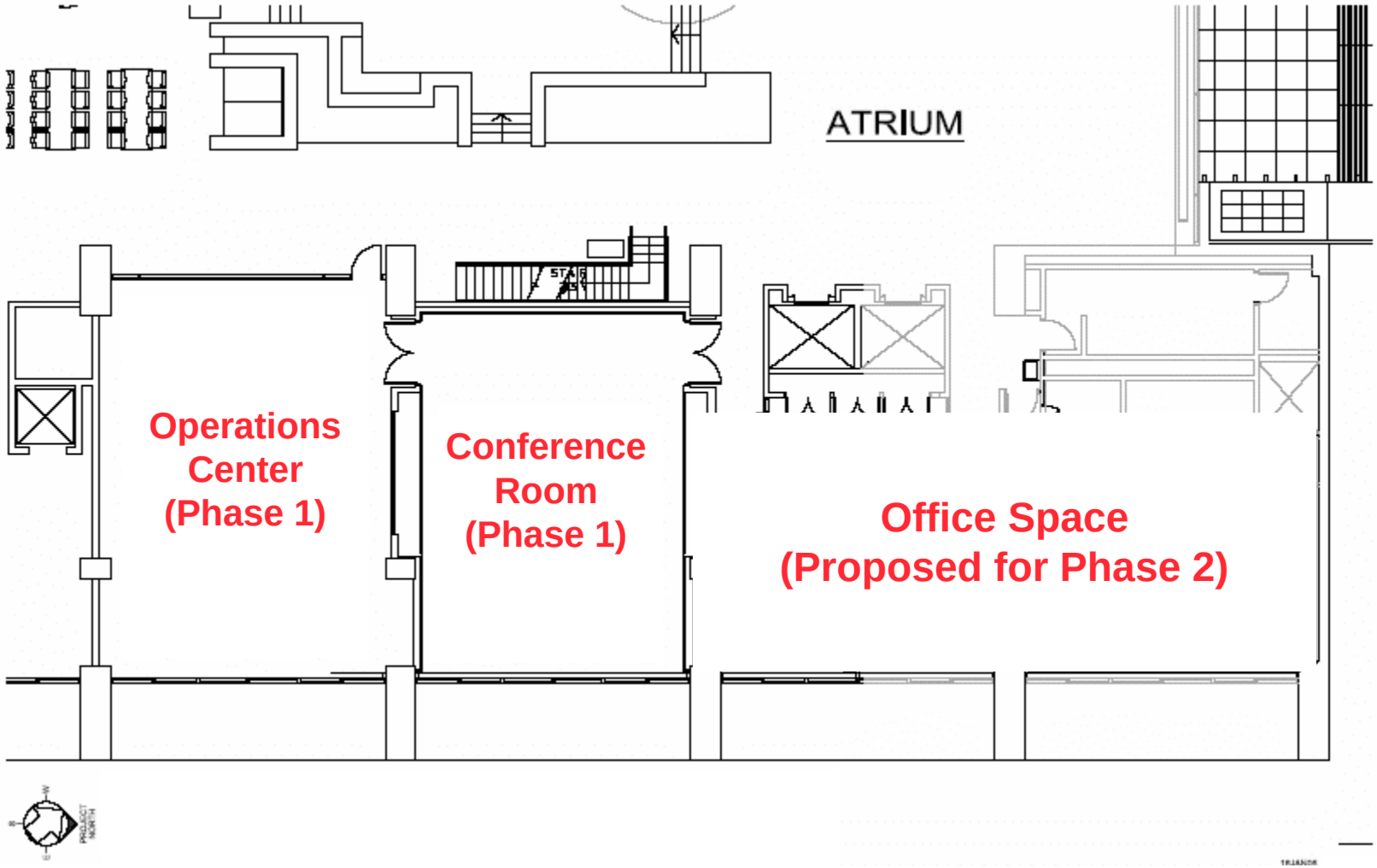
August 2006,
phase-1 MTCC at FNAL ROC.
Getting ready to look at Events

Oct. 31 Evening at FNAL
Nov. 1 Owl at CERN
Taking MTCC-II DQM shift

Histograms being examined and Event Display shown are in 'Real Time'!!!

US-CMS remote operations will move to LHC@FNAL early next year.

LHC@FNAL Location & Layout



Construction of LHC@FNAL

Construction Photo
Oct. 27, 2006

Current Status of Remote Operations Capabilities

- CMS ROC is already in operation for commissioning at CERN
- Construction of a joint LHC and CMS remote operations center (LHC@FNAL) is nearing completion - Spring 2007
- LHC@FNAL Software (LAFS) development effort for accelerator software has been successfully launched. This is a collaboration between Fermilab and CERN.
- Software for LHC, CMS, ILC: Is there overlap with FES needs?
  1. Role Based Access
  2. LHC Sequencer
  3. Sequenced Data Acquisition (SDA)
  4. Screen Snapshot Service (SSS)
  5. Identity Database (IDDB)
  6. LHC Beam Instrumentation Software
  7. Electronic Logbook for ILC
  8. WebEx* (commercial web collaboration tool used by ILC & LHC)

Role Based Access (RBA)

An approach to restrict system access to authorized users.

What is a ROLE?

- A role is a job function within an organization.
- Examples: LHC Operator, SPS Operator, RF Expert, PC Expert, Developer, …
- A role is a set of access permissions for a device class/property group
- Roles are defined by the security policy
- A user may assume several roles

What is being ACCESSED?

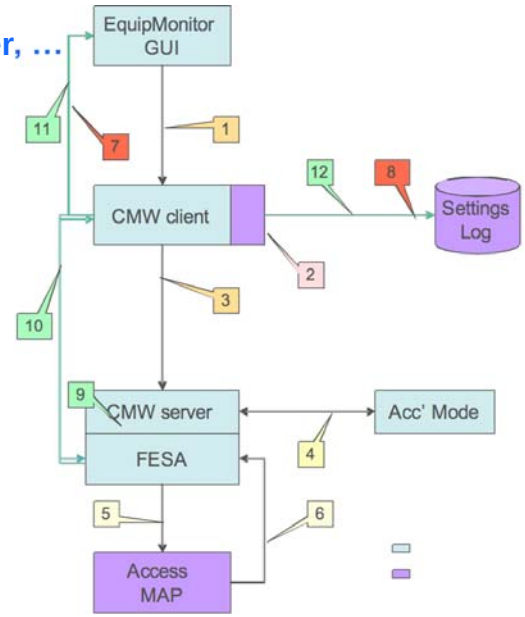
- Physical devices (power converters, collimators, quadrupoles, etc.)
- Logical devices (emittance, state variable)

What type of ACCESS?

- Read: the value of a device once
- Monitor: the device continuously
- Write/set: the value of a device

Requirements have been written

- Authentication
- Authorization



Status: Design document in progress

The software infrastructure for RBA is crucial for remote operations. Permissions can be setup to allow experts outside the control room to read or monitor a device safely.

This is a Fermilab/CERN collaboration working on RBA for the LHC control system.

LHC Sequencer

Automates the very complex sequence of operations required to operate the LHC.

Typical commands

- Set, get, check devices
- Wait for conditions
- Execute more complex operations
- Start regular programs
- Start plots
- Send data to shot log

Step through commands

- Stops on error
- Allow restart at failed command

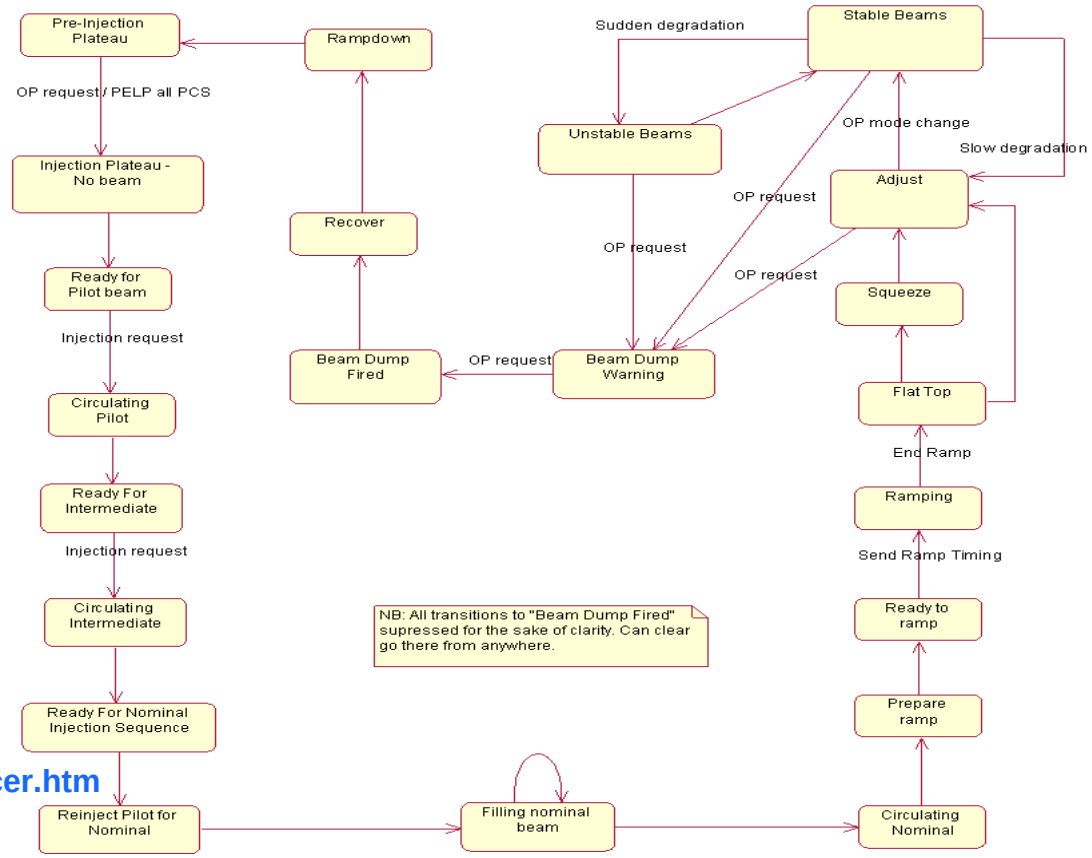
Sequencer is used for:

- Normal operations
- Studies or special cases

Working with CERN on requirements

- Explore existing implementations: FNAL, LEP, RHIC, NIF, HERA, SMI++
- http://cd-amr.fnal.gov/remop/Sequencer.htm

LHC State Diagram



This is a Fermilab/CERN collaboration working on the LHC Sequencer.

Sequenced Data Acquisition (SDA)

SDA is a software system for collecting, storing and analyzing data in terms of the stages of a complex process.

SDA 1

- 1st version of SDA developed for FNAL Run II
- Provides consistent and accurate data from the Fermilab accelerator complex
- Used by operators, physicists, engineers, DOE

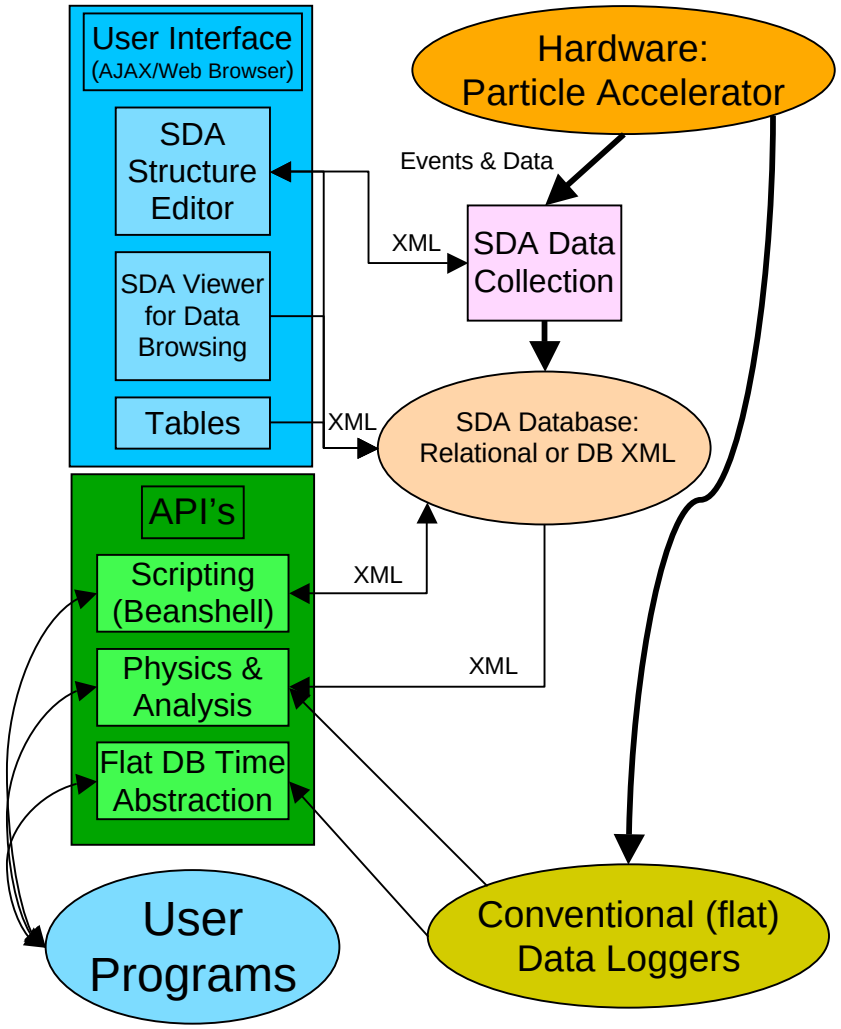
SDA 2

- 2nd version of SDA being developed
- Improved SDA for FNAL
- Development is ~90% completed

SDA 2 for LHC

- Need to establish requirements for LHC with CERN
- "SDA Workshop" on Nov. 16 at CERN

This is a Fermilab/CERN collaboration.



Screen Snapshot Service (SSS)

An approach to provide a snapshot of a graphical interface to remote users.

What is a snapshot?

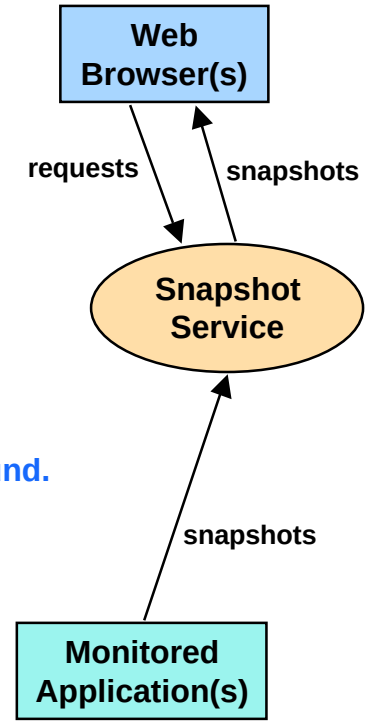
- An image copy of a graphical user interface at a particular instance in time.
- Examples: DAQ system buffer display, operator control program, …
- A view-only image, so there is no danger of accidental user input.
- Initially envisioned for application GUIs but could be expanded to desktops.

What is the role of the service?

- Receives and tracks the snapshots from the monitored applications.
- Caches the snapshots for short periods of time.
- Serves the snapshots to requesting applications/users.
- Prevents access from unauthorized applications/users.
- Acts as a gateway to private network applications for public network users.

How will this work?

- Applications capture and send snapshots to the service provider in the background.
- Users would access snapshots using a web browser.

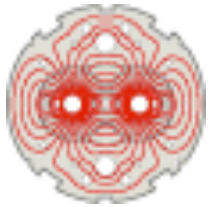


Status:

- The capturing of snapshots from Java applications has been demonstrated.
- The transfer of snapshots is being investigated.

SSS is being developed at Fermilab for CMS, and may be applicable to the LHC.

Identity Database (IDDB)



A lightweight user authentication framework.

Motivation

In order to enable access control in software applications, users need to be properly authenticated. This requires a security infrastructure that maintains user accounts, permissions, and has access to log files. A typical developer usually does not have enough time and expertise to implement and maintain a security infrastructure.

Identity Database

A solution that targets small- and medium-scale applications, both standalone and web-based, such as programs for data analysis, web portals, and electronic logbooks.

Features

- Includes database, application programming interface (API), and web-based user interface for management.
- A single IDDB instance can be shared by multiple programs/systems.
- A single user can be identified by several different types of credentials: username + password, Kerberos, X.509 certificates, IP address
- Access permissions are described by roles, and roles are assigned to users.
- Each application can have its own set of roles, which are managed independently.

IDDB is being developed at Fermilab for an electronic logbook for ILC.

LHC Beam Instrumentation Software

Dedicated applications for LHC beam instrumentation still need to be written.

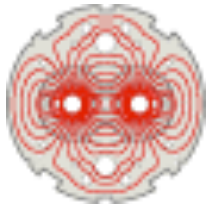
- Tune measurement (including coupling, chromaticity, etc.)
- Wire scanners, synchrotron radiation monitors, etc.

The LHC@FNAL Software (LAFS) team will begin by writing the high-level application software for the LHC tune measurement system by providing panels for device configuration/setup and measurement displays:

- FFT measurement
- Continuous FFT
- Tune PLL
- Chromaticity measurement
- Tune feedback
- Coupling feedback

This is a Fermilab/CERN collaboration working on LHC beam instrumentation software.

Future Capabilities for HEP



Although we are making good progress on the development of remote operations capabilities for HEP, there is room for improvement. Better collaborative tools will contribute significantly to our ability to participate in LHC, and plan for the ILC.

We can benefit from improved communications tools by

- exploiting convergence of telecom and internet technologies (e.g. SIP),
- deploying integrated communications (voice, video, messaging, email, data)
- and advanced directory services for identification, location and scheduling.

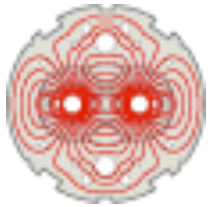
We can benefit from a true collaborative control room by

- deploying distributed, shared display walls for remote collaborative visualization.

We can benefit from security enhancements (role-aware & easier-to-use security).

Some of these needs are already being addressed by Fusion (FES) community.

Additional Slides



LHC@FNAL Task Force

- Erik Gottschalk – Chair (FNAL-PPD)
- Kurt Biery (FNAL-CD)
- Suzanne Gysin* (FNAL-CD)
- Elvin Harms* (FNAL-AD)
- Shuichi Kunori (U. of Maryland)
- Mike Lamm* (FNAL-TD)
- Mike Lamont* (CERN-AB)
- Kaori Maeshima (FNAL-PPD)
- Patty McBride (FNAL-CD)
- Elliott McCrory* (FNAL-AD)
- Andris Skuja (U. of Maryland)
- Jean Slaughter* (FNAL-AD)
- Al Thomas (FNAL-CD)

✓ Task force was charged by the Fermilab Director in April, 2005.

✓ Task force wrote a requirements document and WBS.

✓ Work completed in March, 2006.

* Accelerator Subgroup

The formal LHC@FNAL task force had its last meeting on March 29, 2006.

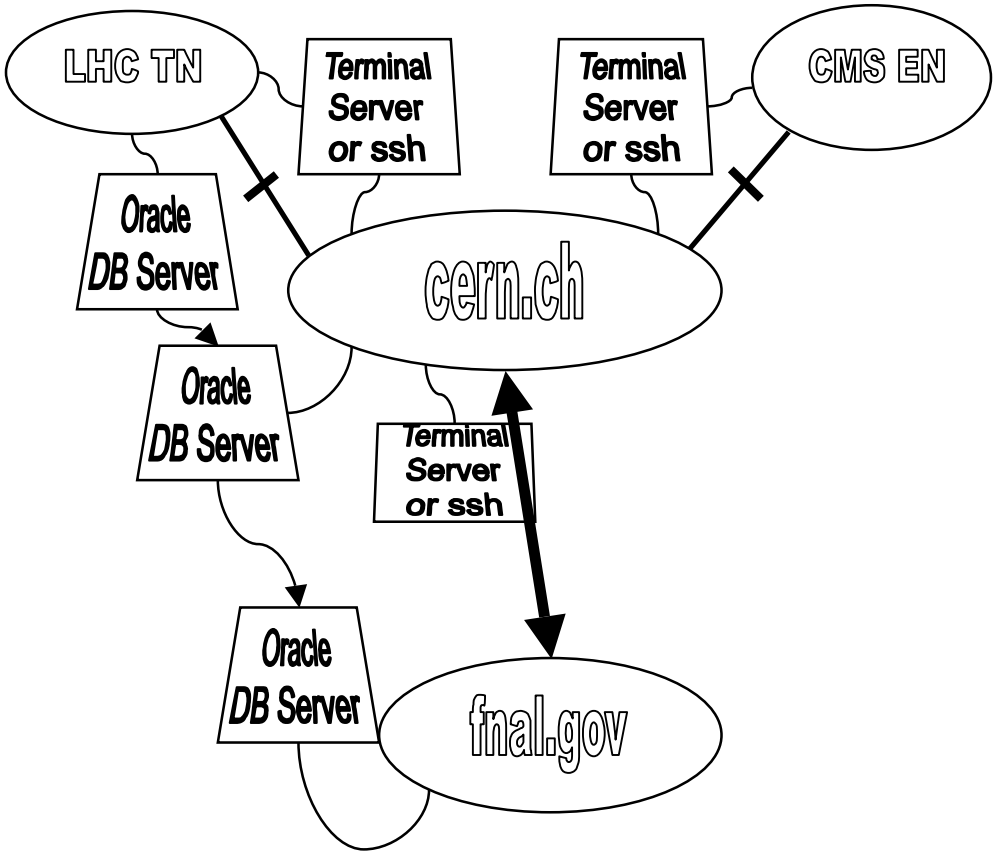
The group has evolved into an integration task force with a new charge and a few new members.

Site Visits

- **Technology Research, Education, and Commercialization Center (TRECC) – West Chicago, Illinois** (Aug. 25, 2005)
- **Gemini Project remote control room – Hilo, Hawaii** (Sept. 20, 2005)
  - http://docdb.fnal.gov/CMS-public/DocDB/ShowDocument?docid=425
- **Jefferson Lab control room – Newport News, Virginia** (Sept. 27, 2005)
  - http://docdb.fnal.gov/CMS-public/DocDB/ShowDocument?docid=505
- **Hubble Space Telescope & STScI – Baltimore, Maryland** (Oct. 25, 2005)
- **National Ignition Facility – Livermore, California** (Oct. 27, 2005)
  - http://docdb.fnal.gov/CMS-public/DocDB/ShowDocument?docid=532
- **General Atomics – San Diego, California** (Oct. 28, 2005)
- **Spallation Neutron Source – Oak Ridge, Tennessee** (Nov. 15, 2005)
  - http://docdb.fnal.gov/CMS-public/DocDB/ShowDocument?docid=570
- **Advanced Photon Source – Argonne, Illinois** (Nov. 17, 2005)
- **European Space Operations Centre – Darmstadt, Germany** (Dec. 7, 2005)
  - http://docdb.fnal.gov/CMS-public/DocDB/ShowDocument?docid=622

Connecting to CERN

Reliable communications tools and robust and secure software are critical for operations.



Some general requirements:

Remote users should see applications used in the main control room(s) when possible. However, they might not have the same privileges.

Communication channels should be kept open.

Establish clear policies for shifts.

The goal is to assist in operations, and not to place additional requirements on CERN personnel.

Issues: access to information on private networks (LHC TN, CMS EN), latency, authorization, authentication, 24x7 communications.

Remote operations for LHC and LARP

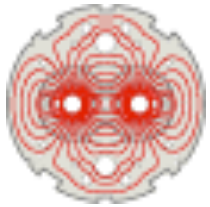
LHC remote operations:
- training prior to stays at CERN
- remote participation in studies
- 'service after the sale': to support components we built.
- access to monitoring information

CCC at CERN

LARP: The US LHC Accelerator Research Program (LARP) consists of four US laboratories, BNL, FNAL, LBNL and SLAC, who collaborate with CERN on the Large Hadron Collider (LHC).

The LARP program enables U.S. accelerator specialists to take an active and important role in the LHC accelerator during its commissioning and operations, and to be a major collaborator in LHC performance upgrades.

LHC@FNAL Software (LAFS)



It will be difficult for outside visitors to make significant contributions to the LHC once beam commissioning has started.

- **Unfamiliarity with the control system**
- **Critical problems will most likely be assigned to in-house staff.**

Fermilab will be more welcomed at CERN if the lab can bring real resources to the table and has the ability to solve operational problems.

- **Fermilab has experience in the software issues of running a collider complex**
- **The Fermilab control system based on Java is similar to the LHC Java based control system and has a large pool of Java software expertise to draw on.**
- **Fermilab is already collaborating with CERN on a number of software projects**

Goal of LAFS: Develop a suite of software products to enable Fermilab accelerator physicists to make key contributions to the beam commissioning of the LHC.

- **A small team of computer professionals, operational experts, and accelerator physicists has been assembled to contribute to select LHC software tasks.**
- **Software projects underway - in collaboration with CERN:**
  - Role Based Access
  - Sequenced Data Acquisition (SDA)
  - Sequencer
  - High-level beam instrumentation

FNAL ROC and MTCC

Coordinated effort with CERN MTCC Operation/Computing/Software groups.

MTCC-Phase 1

Goal and Strategy (DQM was not running continuously at Point 5):

- transfer events to FNAL
- locally run available DQM programs and event display systematically
- make results easily accessible to everyone as fast as possible
- Take shifts to contribute to the MTCC operation by doing quasi-online monitoring.

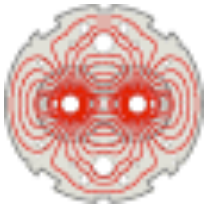
MTCC-Phase 2

Goal and Strategy (DQM programs are running more systematically at Point 5):

- Do real time Data Quality Monitoring by looking at DQM results running at Point 5 and take official DQM shifts.
- Run Event Display locally on events transferred in real time.
- Continue to do quasi-online monitoring as in Phase-1 with the transferred data. This has the advantage of running on every event, and it is possible to do reprocessing with improved programs with good constants.

We have achieved both the phase 1 & 2 goals!

Some assumptions (CMS operations)



For CMS

- CMS will have a shift schedule, a run plan, and a protocol that defines responsibilities and roles of shift personnel. We assume that a shift leader is responsible for CMS shift activities.
- LHC@FNAL will have shift operators who will be able to assist US-CMS collaborators with CMS activities during commissioning and operations.
- LHC@FNAL will participate in CMS shifts. Neither the duration nor the frequency of the LHC@FNAL shifts has been determined.
- The CMS Collaboration will have a protocol for access to the CMS control system (PVSS), and a policy for how access to the control system will vary depending on the physical location of an individual user.
- The CMS Collaboration will have a policy that defines how DAQ resources are allocated. This includes allocation of DAQ resources to various detector groups for calibration and testing.
- The CMS Collaboration will have a protocol that defines how on-demand video conferencing will be used in CMS control rooms and LHC@FNAL.
- The CMS Collaboration will provide web access to electronic logbook and monitoring information to collaborators worldwide
- The CMS Collaboration will maintain a *call tree* that lists on-call experts worldwide for each CMS subsystem during commissioning and operations

For both CMS & LHC

- LHC@FNAL will comply with all CERN and Fermilab safety and security standards.